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DISTINCTIONS OF AUDITORY ANALYZER FUNCTIONS DURING PROLONGED EXPOSURE OF MAN TO CHANGED GAS ENVIRONMENT /1*

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Experience in preparation and conduct as well as the prospects of future development of space flights are indicative of the practical importance of studying constitutional reactions, and in particular the auditory analyzer, when man is exposed to an altered gas environment for long periods of time.

The studies of different authors reveal the considerable resistance of the auditory analyzer to the effect of acute hypoxia and high CO_2 content (I.G. Kulikovskiy, 1939; A.P. Popov, 1938; I.Ya. Borshchevskiy, 1958). A.P. Popov (1938) established that there is little change in acuity, with only a tendency toward its decrease under the influence of brief respiration of a mixture containing 8-10% O_2. Nor was any deterioration of hearing detected during respiration for several minutes of mixtures with low oxygen content (to 12%), and in some experiments it was established that there is even an increase in threshold sensitivity at high frequencies.

In the presence of acute hypoxia loss of hearing may occur only if a fainting state develops, which is significant for the practical activity of the pilot and cosmonaut. The data submitted warrant the belief that in the presence of acute hypoxic states the primary role in the mechanism of possible hearing disturbances belongs to the central, including cortical elements of the auditory analyzer which are the most sensitive to oxygen deficiency. /2

The continuous extension of space flights has confronted the researcher with the task of investigating the adaptation capabilities of the organism in the presence of continuous and prolonged [many days] exposure of man to a number of factors, including the artificial atmosphere in the cabin. Some authors believe that there are some advantages to the change in gas composition in the cabin during prolonged space flights. Thus, replacement of nitrogen in the cabin air by helium may rule out the deleterious effect on man of induced radiation, it will reduce the take-off weight of the ship, etc. (A.G. Dianov, A.G. Kuznetsov, 1963). The opinion has also been voiced that the excess CO_2 in the cabin air may be used for oxygen regeneration in the photosynthesis system, for prevention of hypocapnia, to diminish the deleterious effect of cosmic radiation (S.G. Zharov et al, 1963).

*Numbers in margin indicate pagination in original foreign text.

In spite of its practical importance, the matter of the influence 2
of factors related to the artificial atmosphere of a space ship on human auditory function has been studied very little, which is the reason for the need of special experiments.

A study of auditory function was conducted with a man who was exposed to an artificial atmosphere for 25-30 days. A total of three series of experiments was conducted. In all of the experiments determination was made of the hearing threshold through air conduction at frequencies of 125, 250, 500, 1000, 3000, 4000, 6000, 8000 cycles per second and time of reverse adaptation at a frequency of 1000 cycles per second following three minute exposure to a 90 decibel white noise. All of the methodological procedures were modified to apply to conditions of man's /3
multiday stay in a small pressurized cabin.

In the first series of experiments of multiday stay under conditions of low barometric pressure (380 mm Hg [millimeters of mercury]) and normal oxygen pressure (150-160 mm Hg) the dynamics of auditory sensitivity was characterized by some instability (A.G. Kuznetsov, N.A. Agadzhanyan, 1963). The highest values for auditory threshold were noted during the first half of the experiment. Thereafter, against a background of some constant scatter of thresholds of auditory sensitivity, all of the subjects presented a tendency toward a relative rise. Processing of the results by the method of lowest squares (Ye.S. Ventsel', 1960) revealed that the general tendency of auditory changes graphically approximates a straight line successively nearing the abscissa. On different days of the experiment the adaptation time ranged from 45-70 to 110-150 seconds. This test is rather labile, no definite direction is detected. Upon cessation of prolonged exposure the auditory thresholds under quiet conditions did not differ from initial levels. Consequently a multiday stay under low barometric pressure with normal partial oxygen pressure has no substantial influence on auditory function.

In the second series of experiments the subjects remained for 30 days in an atmosphere containing 1 to 2% CO_2 (S.G. Zharov et al, 1963), no marked changes were observed in the dynamics of auditory thresholds and time of reverse adaptation. However there was rather a significant tendency toward a rise of auditory thresholds during the first six days of a multiday experiment. Thus, on the first day, the auditory threshold was /4
15-17 decibels higher than on the 21-22nd day of exposure. Upon termination of the experiment no signs of auditory fatigue were observed in the subjects. Thus, a 30-day stay by man under conditions of a 1 to 2% Co_2 concentration did not reveal an adverse influence on the auditory analyzer.

The third series of experiments consisted of a study of auditory function during a 25-day stay under conditions of breathing a helium-oxygen mixture. A maximum and unidirectional increase in auditory thresholds was detected upon shifting from the ordinary atmosphere to helium-oxygen. The fluctuations of auditory thresholds on different days did

not exceed the usual physiological values. Adaptation time changed within a range of 40-180 seconds. Upon conclusion of the experiments the auditory thresholds in quiet conditions essentially coincided with the background data. This permits us to conclude that man's exposure to a helium-oxygen mixture does not have a specific effect on the auditory analyzer. 4

The rise in auditory thresholds during the first few days of a multiday experiment may be interpreted as an initial adaptational reaction of the auditory analyzer in response to new factors. A marked shift from the usual environment to helium-oxygen is associated with a reorganization of many previously formed stable habits. These conditions make other demands of the organism and first of all of all the higher branches of the central nervous system and they induce the corresponding adaptational reactions which are often nonspecific. Thus, in our experiments very different atmospheric factors (low barometric pressure, high CO_2 content, replacement of atmospheric nitrogen by helium) induced the same type of reaction of the auditory analyzer. The stabilization of auditory threshold observed in all of the experiments during the second and third week is, in our opinion, an expression of successfully achieved adaptation of the organism to the new conditions. 5

However, it must be noted that we detected such stabilization of auditory function only under the effect of factors that did not elicit appreciably deleterious effects. Of extremely great interest is the phenomenon of relative sensitization of hearing discovered in the second half of multiday experiments. The mechanisms of these phenomena encountered in dynamic audiometry in individuals who remained in small pressurized cabins for long periods of time can be discussed only hypothetically. It is hardly likely that the increase in excitability of central portions of the auditory system underlying sensitization is due to intensification of excitatory processes in the cerebral cortex. S.G. Zharova and V.A. Il'ina, 1963, demonstrated that when man was exposed to low barometric pressure and high concentration of carbon dioxide for long periods of time, the electroencephalogram showed inhibition of alpha rhythm, decrease in its amplitude, with appearance of diffuse slow waves. These symptoms are related to intensification of inhibitory phenomena in the cortex of the cerebral hemispheres.

As it is known, in the presence of cortical inhibition there is disinhibition of subcortical centers. It may be assumed that the increase in auditory sensitivity during the second half of a multiday experiment is related to adaptation-trophic influence on the auditory centers. However these questions require special definition. 6

Many authors (G.V. Gershuni, 1959; A.V. Antropov, 1959; A.I. Vozhzhova and I.A. Sapov, 1961; L.S. Khachatur'yants, 1963, and others) believe that the change in time of reverse adaptation is related first of all to the state of the central parts of the auditory analyzer. Therefore, intensification of inhibitory processes in the cortex of the cerebral

hemispheres during the second half of the experiments was evidently what induced an extension in time of reverse adaptation. 6

While in an atmosphere containing 3-4% CO_2 for a few hours the subjects presented a 20-25 decibel rise in auditory threshold over the entire range of tested frequencies.

These studies revealed that the comparative evaluation of auditory analyzer reactions in man during prolonged exposure to space flight factors made it possible to determine ranges of fluctuations of auditory threshold indicative of an adaptation effect or else of cumulation of deleterious stimuli. Thus, at an auditory threshold fluctuation under 10-15 decibels there is stable adaptation to new conditions. But with increase of auditory sensitivity thresholds to magnitudes above 20-25 decibels, there is depletion of adaptation mechanisms, analyzer fatigue. In this case the indicated changes in the auditory system usually correlate with the psychophysiological and some vegetative indices.

The results obtained are indicative of the considerable resistance of the auditory system under conditions of an altered gas environment, and they may be used to determine the fluctuations of hygienic parameters pertaining to inhabitability of spaceship cabins. 7

Summary

A study was made of auditory analyzer function when man is exposed for many days to low barometric pressure (308 mm Hg) with normal partial oxygen pressure; of the effect on man of an atmosphere containing up to 2% CO_2 and breathing a helium-oxygen mixture. Dynamic audiometry and a study of reverse auditory adaptation time failed to reveal deviations in excess of the usual physiological fluctuations. The human auditory analyzer was found to have significant resistance during multiday exposure to an artificial atmosphere.

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